memory, recognition, abstraction, symbols, etc. The second chapter treats of the coherency of experience, laying greatest stress upon the principle of the economy of thought. We have here a treatment of subject and object, etc. In the third chapter psychical analysis and the notion of unperceived contents of consciousness are developed. Succession, time, attention, perception, and the concept of number, etc., here receive consideration. The fourth chapter discusses sensation, memory, and imagination; the fifth, the objective world, including the problem of the thing-in-itself, objective space, the facts of geometry, vision, etc. The sixth chapter is more logical in content, and deals with truth and error. In the seventh chapter we have feeling and will discussed.

The language and purpose of Dr. Cornelius are clear. The points on which he insists are points deserving emphasis. As to method his attempt is significant. If a science of psychology in the sense of the other sciences is ever built up, it must be upon some such foundations, and whether one agrees with Dr. Cornelius's detailed accomplishment of his task or not, one must nevertheless accord to him the credit of having approached his subject from a novel and fruitful point of view. From merely *envisaging* the subject in this manner, one can derive great profit

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THE LIVING SUBSTANCE AS SUCH AND AS ORGANISM. By *Gwendolen Foulke Andrews*. Supplement to Vol. XII. of *Journal of Morphology*. Boston: Ginn and Co.

The chemist refers the qualities of all substances to the different combinations of different atoms. The physicist starts with the molecule. What is the vital unit, to whose changes and combinations the biologist can refer differences between different tissues and organisms?

The oldest theories concerning life would seem to regard it as an energy radiating from some controlling centre in the blood or nervous system and thus vivifying a comparatively inert mass. Only comparatively lately has its inherence in every part of the organism been universally accepted. Only when this view of life as pervading or characterising every part of the organism, has been established, could there be any serious search for life-units,

This inquiry has been practically the work of the present century, although about a hundred years ago Bichat showed that the body was composed of a comparatively small number of textures or tissues which recurred in the most different organs. The theory of the cell as the fundamental constituent and true morphological unit of the body is but little more than fifty years old. These little masses of protoplasm, each having its own more resistent centre, the nucleus, and surrounded by its membrane certainly seemed to be the true and fundamental vital units. The apparently homogeneous protoplasm possessed all the vital powers and could perform all functions, the nucleus was regarded as hardly more than a little less fluid condensation of the protoplasm, the cell-membrane gave the mass indi-

viduality. Egg and spermatozoon were found to be single cells, the earliest embryonic stages are evidently little clusters of similar cells, every cell arises from a pre-existing cell, and every tissue arises from, and is composed of, cells. What better or more fundamental unit could be asked?

So Virchow speaking on this subject in 1858 could say: "Every animal presents itself as a sum of vital unities, every one of which manifests all the characteristics of life. . . . A so-called individual always represents a kind of social arrangement of parts, in which a number of individual existences are mutually dependent, etc." And Haeckel restates, only more emphatically, the same thought when he calls the animal a "cell-republic."

That the cell is a morphological unit possessing a certain degree of individuality cannot well be denied. Every living body is certainly composed wholly of cells and their products. But in spite of all this we may not be looking at the animal from the best standpoint when we call it a cell-republic.

For the extreme exponents of the cell theory in emphasising the individuality of the cell seem often to lose sight of the individuality of the organism. Against this one-sided view strong protests have already been made.

Thus many years ago Huxley wrote: "They (the cells) are no more the pro-"ducers of the vital phenomena than the shells scattered along the sea-beach are "the instruments by which the gravitative force of the moon acts upon the ocean. "Like these, the cells mark only where the vital tides have been, and how they "have acted."

Mrs. Andrews's monograph is a valuable contribution to biological science bearing directly upon this view. It is the result of years of patient and laborious observation. She has studied the living substance in its living condition. And the difficulties and discouragements of such study can be appreciated only by those who have attempted the same thing and have given it up in despair. The author supports in the main Bütschli's view that protoplasm is a microscopic foam, composed of exceedingly minute vesicles containing various solutions surrounded by films of a more viscous material. But even these viscous films are composed of a finer foam or emulsion. The fluid drops are separated from one another by the films, while these latter unite to form a continuous structure like a honey-comb. The continuous substance is the essential living material.

The continuous substance is continually changing in viscosity, arrangement, and function. The pseudopodia, or long slender processes of an amœba, may "extend like stiff bristles, or bend about like tactile organs, or lash the water like overgrown cilia or flagella. But a momentary touch upon the cover glass will in one moment convert all this display into inactivity, leaving but a shapeless lump. (P. 29.)

About twenty-five pages are devoted to "Areal Differentiation," i. e., the appearance of protective, contractile, transmissive, and other areas within the living substance of the simplest animals, and in developing eggs. "In the so-called 'low' "and 'primitive' forms of life, the substance-organisation is seen to be very com-

"plex, if here as in the metazoa the sum of all areal differentiations be taken as the "unit of count; but it is less stable and more fleeting,—often, indeed, to the point "of evanescence. Grosser structures are openly transmuted, whereas in the adult "higher forms there is a more stable mask of structure behind which the substance "carries on its unstable processes." (P. 65.) And even in the most stable tissues of higher animals local transformations and transmutations of areal structure are continually taking place. These, however transient, are the substance organs in distinction from the so-called organs of the individual organism.

Having shown the structure and areal differentiation of the living substance the author proceeds to Protoplasmic Activities and Cell Division. Perhaps the most interesting pages in this section are those on the filose formations or "thread-spinnings" of protoplasm. These threads were protruded abundantly by protozoa from their exposed surfaces and are hardly to be explained, if at all, by the mere physical surface-tension of a foam-structure. They occur also in the earlier embryonic stages, spun from cell to cell. "Since in certain eggs in the 8-16-celled "stage, in which the cells had been induced by continued pressure to separate "quite widely from each other while continuing their filose activities, the order of "cleavage and arrangement of cells in the characteristic spiral was not changed, it "seemed clearly proven that by the filamentous connexions there was maintained "true correlation and interaction of cells, notwithstanding a separation of their "pellicular surfaces. The fact that such was the case was noticed and pointed out "by Dr. Whitman long before I discovered the actual means by which the seem-"ingly inhibitory conditions were transcended." (P. 77.)

In eggs in the 4-16-celled stages the cells were caused to separate by more rapid and sudden pressure. "If actually separated, but without rupturing the "membrane perceptibly, as was done a number of times by pressure of a mixed "rolling and squeezing nature, the cells passed soon after through a great change "of viscosity, visibly relaxing. They then showed rather marked change of con-"tour, and afterward renewed their spinnings until once more connexion was re-"established amongst themselves, when by degrees they drew more and more closely "together until they touched. The walls then coalesced and the two, four, six, "eight, twelve, or more, cells were again a solid mass. . . . There can hardly "be a doubt but that there is here shown a definite physiological resistance to cer-"tain adverse mechanical conditions in environment; that the living substance re-"sponds in character of its own powers to stimulus of a given sort; that this "response is to conditions which are probably new to the substance, and is, more-"over, contrary in its nature to that given by purely physical foams." (Pp. 83, 84.)

The sections on the "New Structural Formula for Protoplasm" and the "Living Substance as Such, and as Organism," are full of thought, suggestion, and interesting observations, but must be read in their entirety to be appreciated.

The True Biological Standpoint from which to consider the living organism is therefore, according to our author, not the cell, nor the tissue, nor the organ, but

the substance itself in which cell, tissue, and organ are but areas of differentiation. Even the individual organism itself is but a means to the development of the substance through which it may attain an ever higher condition. The strongest and fittest substance, and that most powerful to control its environment, survives. The survival of the fittest is the survival of the fittest substance.

In the section on the Selection of Environment by the Living Substance special emphasis is laid on the internal environment of the substance in the contents of the foam vesicles. "This is more or less completely within its control, yet in-"fluences it largely and even to some extent controls it, physically and chem-"ically." "External environment represents rather opportunities for the organ-"ised living substance. Internal environment represents at a given moment not "only opportunities but intrinsic necessities for the substance." "From this "standpoint the organism appears in the guise of a machine or device framed by "the substance as such to secure its own specific internal environment." "Sub-"stance habit . . . has always been along lines of increased control, direct or indi-"rect, of external environmental conditions." But scattered quotations, taken out of their connexion, can give but a poor idea of the thought and argument.

The standpoint of the author can perhaps be best seen from the following extract from the section on Heredity (p. 151):

"Up to this point it has been cumulatively shown that cell phenomena are "underlain by such phenomena of the continuous substance as would seem to in-"hibit us from using cells, even broadly, as primary units of physiological organi-"sation;—the new facts urging us to trace substance phenomena in a physical and "physiological continuity throughout all parts of organisms; to ignore cell-limits, "except as they fall within this interpretation; to see in cell-walls and in nuclei "local and even temporary substance-organs belonging primarily to the mass and "but secondarily to cells, their curious repetition being taken in relation to general "needs of the substance as such rather than as parts of cells as units of structure; "—in short to study cells as localities in a mass organisation of the continuous sub-"stance and as local expressions of substance habit in a significantly common "grouping. . . . Organs no longer appear as compounds of certain different sorts of "cells, but as a complex of minute substance-organs whose multiplication baffles "even the imagination, for they not only extend in a lessening series into the in-"visible subdivisions of the continuous substance but are constantly being trans-"muted into new strnctures."

We must leave important sections of the work entirely unnoticed. The great mass of observations and suggestions, many of them exceedingly interesting, cannot be touched in a review. The work is crowded with them. Indeed the line of argument often seems to be lost in the mass of facts adduced in its support or of inference from these. Sentences too are often obscure and require careful perusal before the exact meaning can be perceived. But the thought is there and will repay the effort of the reader.

To many, doubtless, the author will seem to have gone to an opposite extreme as far from the true mean as the position of the most bigoted cell theorist. But the evidence is continually increasing that the substance, rather than the cell furnishes us the true standpoint from which to study and explain the facts of anatomy and physiology. It is gradually becoming clear that cells are only subordinate, and by no means ultimate, fundamental, or comparatively independent, centres in one mass of substance, controlled by the organism as a whole. The theory of the organism which makes it a mere multitude of co-operating cells, like that theory of state-rights which makes of our nation a mere confederation of states, is liable to lead to very unsafe deductions. We must continue to speak of cells with their different powers and structures, but we must remember that cell-structure is only an areal differentiation in one mass of substance, and that its powers are delegated by the organism. One substance, characterised by sensibility, irritability, or by whatever name we may choose to call it, continuous through the organism, and passing in the reproductive elements from generation to generation through all the chain of life in time past and present, ever changing and yet persisting, resistent and yet indefinitely adaptable;—such a substance would seem to furnish the basis for all vital phenomena.

But what becomes of our search for the vital, morphological units? We can hardly think, much less argue, concerning protoplasm without postulating something of the kind. We talk learnedly of physiological units and pangens, of plastidule and biophore. But we know only substance. But is there one fundamental substance, protean in its functions? Certainly protoplasm seems to be a mixture of various chemical compounds. Still all these substances may be merely more definite areal differentiations of one primitive protoplasm. Even if we could arrive at one primitive, homogeneous, living substance, would the real difficulties in the way of an understanding of its functions and powers be lessened? We cannot see that they would. The correlation between structures and actions of different parts of a homogeneous substance would seem less rather than more conceivable. This is the great enigma of life; the "fitsomeness" of the substance, the conformity of it to its inclusions and the molding of them to it, the fitting of its parts to one another and of itself to its environment. And from the solution of this enigma we seem as far removed as ever.

JOHN M. TYLER.

THE CHANCES OF DEATH AND OTHER STUDIES IN EVOLUTION. By *Karl Pearson*, M. A., F. R. S. With Illustrations. In Two Volumes. London and New York: Edward Arnold, Publisher.

The title of this book renders the first essay more prominent than the rest of the articles, and is apt to give a wrong impression to the book-buyer who glances over the pages of a catalogue. The book consists of a collection of essays on most various topics—the Roulette of Monte Carlo; Reproductive Selection and Its Chances; Woman and Labor; Woman as a Witch; the Passion Play, a Study of